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Solid Earth
Discussions

Interactive comment on "Erosion rates deduced from Seasonal mass balance along an active braided river in Tianshan" *by* Y. Liu et al.

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1 General comments:

We first would like to thank A. Crave for his insightful and very positive review. We shall address his comments below and start by the general comment.

Results show mechanical denudation rate lower than other studies on mountain ranges contexts. Undoubtedly the relatively lower mechanical denudation rate is induced by the low precipitation rate on Tianshan. But I wonder if Tianshan range, and specifically the upper part of the range with U-shape morphology, where this study has been done, present different statistical slope distribution and seismic activity comparing other

places sited in the text (Haut Glacier d'Arolla, Siachen Glacier, Anapurna watershed, Kuitun river and Taiwan). In section 6.1, present day mechanical erosion rate comparison between the former areas would be more relevant with such additional informations about slopes and seismicity.

This is a very interesting question. According to your suggestion we have looked at the slope distributions and seismicity. No simple picture emerges that would attest the primary control of morphology or seismicity compared to hydrology and meteorology. This, in itself, is an interesting conclusion and therefore we propose to add the following comment and figures as a closure to the discussion of section 6.1.

"In order to look for a possible influence of morphology we compared the cumulative distribution functions of slopes in the Arolla, Annapurna, Kuitun, Siachen Urumqi and Taiwan island catchments morphologies. We used SRTM 4 or ASTER 2 DEMS when available to compare the distributions. Fig 1a shows the computed CDFs. A group of four catchments (Arolla, Annapurna, Kuitun, Urumqi) has comparable slope distributions for at least 60 % of their drainage area. Two catchments exhibit a clearly different slope distribution : Siachen and Taiwan. The Siachen catchment exhibits are very distinct trend because of the Siachen glacier that covers most of the catchment and has gentle surface slopes that are not corrected for in DEMs. Catchments in Taiwan island have significantly smaller slopes then the other catchments. It has to be noted also that the Annapurna catchment has more surface with high ($> 40^o$) slopes than the other catchments. As a simple and complementary way to graphically test the similarity in distribution functions of the slope datasets we used Quantile-Quantile plots (QQ-plots). (NIST/SEMATECH, 2009; Metivier and Barrier, 2012). The quantiles of the slope CDFs for each catchments are compared to the corresponding quantiles of the slope distribution in our survey area (the Urumqi Glacial Valley). If the datasets are comparable (derived from the same distribution function), then the QQ-plots align on a 1:1 line. Fig 1b shows the result. Again Taiwan and Siachen, as expected, show a clear departure from the 1:1 correlation for low slopes. Let us note though that Siachen tends towards the 1:1 correlation for large slopes, hence above the glacier surface. The Quantiles of the Annapurna slope distribution departs from the 1:1 line correlation with the Urumqi for large slopes and, but to a lesser extent, for small slopes. The Quantiles of Arolla also show a slight departure for the largest slopes.

We are not aware of studies showing that erosion concentrates on the highest slopes of the Annapurna and Arolla basins and that this could be the reason why sediment load are higher in these catchments compared to the Urumqi river. Furthermore the Taiwan catchments have much smaller slopes then the other one yet Taiwanese rivers carry the highest load. This therefore suggest that differences in slope distributions can probably not be advocated to explain the order of magnitude differences in reported loads in these rivers.

Tectonic uplift could also play a significant role. Unfortunately Quaternary exhumation rates remain unknown in Tianshan. It is therefore impossible to compare with published exhumation rates in the western Himalayas (Zeitler, 1985; Foster et al., 1994), or in the Alps (Wittmann et al., 2007). At a much shorter timescale, Contrary to Taiwan, seismicity is probably not an issue in the case of the Annapurna, Arolla, Kuitun, Siachen and Urumqi catchments. For the Siachen and Annapurna catchments the first M>6 historical eartquakes recorded are almost 300 km away (National Geophysical Data Center / World Data Center (NGDC/WDC) Significant Earthquake Database, Boulder, CO, USA. (Available at http://www.ngdc.noaa.gov/nndc/struts/form?t=101650&s=1&d=1)). in the case of the Urumqi river (if one excepts the chinese M~ 6 nuclear tests), there are nine M>6 earthquakes below the same distance and two for the Arolla catchment. By contrast more than 30 earthquakes of $M \geq 6$ are reported in the NOAA catalogue within 300 km from the Taiwan island center. Thus no picture emerges because cachments with high loads have experienced no large historical earthquakes (Annapurna), few (Arolla) or many (Taiwan) whereas the Urumqi river has experienced both historical and nuclear explosion earthquakes yet its load is small. "

2 Specific comments:

1. *Title should be changed. There is no reference to the " active braided " river properties in the text.*

   The title has bee changed into “Erosion rates deduced from Seasonal mass balance along the upper Urumqi river in Tianshan”

2. *Page 547, line 3 : I prefer " runoff " with is general sense instead of " precipitation ". Glaciers are built with precipitations.*

   We changed the term accordinlgy

3. *Page 548, line 13 : A short explanation (one sentence) about reasons discussed by Liu et al. 2008 would be appreciated;*

   We modified the paragraph which now reads : "Liu et al. (2008), through a comparative analysis, have shown that cross-sectional sampling could lead to an order of magnitude bias in the flux measured. They furthermore showed that cross-section samples did not enable to catch the full range of flow conditions. We therefore did not follow the cross-section average sampling procedure."

4. *Page 550, line 20 : you can insert " (Fig 4) " after " within 20%. "*

   Done.

5. *Page 552, line 16 : precise which " levels "*

   We changed “levels” into “water levels”

6. *Page 552, line 20 : usually summer has 3 months, precise that % inidcated line 19 are for two months.*

   We changed to “during the two first monthes of summer.”

7. *Page 558, lines 13- 15 : to demonstrate a non dilution effect, a variable dissolved mass production is the best argument. Could you verify this with your data ? -*

   We do not understand this point. The fact that concentration varies as a power of discharge with an exponent of ≈ -0.2 clearly rules out dillution as an order one explaination for the variation of concentration with discharge which, for pure dillution, implies an exponent of -1. The paper of Devauchelle et al. (2011) and Godsey et al. (2009), cited in the text, demonstrate this with theoretical arguments.

8. *Page 560, lines 14-15 : I don't understand the significance of 2.9 for Vs,full calculation. Could you develop this ? Vs,av is definitely not a volume but a mass. I have the feeling that Vs,full and Vs,av have not the same dimension and cannot be compared. I am wrong ?*

   You are both right and wrong. We are talking of mass indeed. But contrary to your belief the two terms we calculate have the same dimension. we have included intermediate calculations to be more complete in the text which now reads: " Using the relationships (7) and (8) between the mass concentration and discharge together with (11), we can then calculate the mass flux $q_{s,full}$ transported during the rising limb of the hydrograph (the same can be performed for the falling limb using (12)). For solid load, equations (8) and (11) lead to

$$q_{s,full} = C_{solid} * Q = 37Q^{1.9} = 37[(Q_{max}/T)t]^{1.9} \quad (1)$$

   The mass $M_{s,full}$ that has been transported during a half cycle T is then

$$M_{s,full} = \int_0^T q_s dt = \int_0^T 37[(Q_{max}/T)t]^{1.9} = 37Q_{max}^{1.9}T/2.9 \quad (2)$$

   In the case where $Q = 0.5\langle Q_{max}\rangle$ equation (2) becomes

$$M_{s,av} = 37(Q_{max}/2)^{1.9}T \quad (3)$$

   the ratio of (2) and (3) leads to $M_{\mathsf{s,full}}/M_{\mathsf{s,av}} \sim 1.3$. In the case of dissolved budgets the ratio of these volumes is $M_{\mathsf{d,full}}/M_{\mathsf{d,av}} \sim 0.96$. "

9. *Fig 5, caption : "perfect agreement line " is a dark line not a dashed line.*

   Caption has been modified

10. *Fig 8 : symbols for suspended and bed load should be changed. Currently they are to similar.*

    We changed the labels.

References

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Interactive comment on Solid Earth Discuss., 3, 541, 2011.

Fig. 1. **(a) Cumulative distribution functions of slopes** in the Arolla, Annapurna, Kuitun, Siachen and Urumqi catchments. **(b) Quantile-Quantile plots of slope distribution** in the Arolla, Annapurna, Kuitun and Siachen catchments compared to the Urumqi Glacial Valley catchment. Data derived from SRTM V4. and ASTER V2 DEMS. Tests where perfomed to insure that the difference in grid spacing did not significantly bias the results.ASTER GDEM is a product of METI and NASA

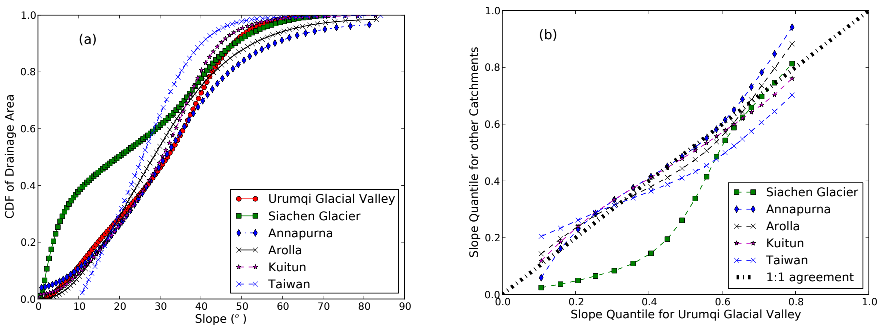

Fig. 2. See caption for this figure at the end of reply